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"Heat Master Fire Control Robot and Alert Network"

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Abstract

This study introduces a partial implementation of a fire safety solution to address the critical issue of fire accidents. It focuses on integrating an autonomous fire-fighting robot and a synchronized alert system, aiming to swiftly detect and suppress fires while notifying relevant stakeholders and occupants. The autonomous robot, equipped with an Arduino Mega 2560 microcontroller and a specialized flame sensor, enables rapid fire detection and suppression through C programming. Simultaneously, the alert system disseminates notifications via SMS, email, and auditory alarms. This half implementation is expected to reduce response times to fire incidents, enhancing evacuation protocols, risk mitigation, and firefighting coordination. The significance of this project lies in its potential to revolutionize fire safety practices, ultimately contributing to the preservation of lives and property.

Keywords:- Fire-fighting robot, Arduino Mega 2560, Flame sensor, C- Language, etc.

1. Introduction

Fire incidents pose grave threats, with potential loss of life and extensive property damage. In response to the challenges faced by human responders in hazardous environments, this study explores a partial implementation of an integrated fire management solution. It addresses a range of fire-related incidents, from actual fires to smoke and gas leaks, through the development and partial implementation of an autonomous fire detection, suppression, and alert system.At the heart of this solution is an autonomous fire-fighting robot equipped with SMS and call alert functionalities, focusing on rapid notifications to registered phone numbers linked to the affected building's location. This advanced robot excels in autonomous fire suppression, reducing response times and enhancing fire management.

Fire detection relies on strategically placed flame and smoke sensors. This study highlights the transformative potential of an advanced autonomous fire management system, In cases of insufficient suppression, the robot initiates SMS alerts and phone calls to registered numbers, promoting active firefighting participation.The unpredictable nature of fire scenarios underscores the urgency of this integrated solution, emphasizing the preservation of lives and resources. This partial implementation involves an automated fire-fighting robot with sensitive flame sensors, Arduino-based control, and water-based suppression for swift and accurate fire response. The robot's methodical approach ensures safety and synchronization with notifications, fostering effective collaboration during fire emergencies.

2. Literature Survey

In recent years, the field of robotics has witnessed remarkable progress, driven by innovative designs and technological breakthroughs, leading to diverse applications. Within this context, our motivation to develop a fire extinguishing robot stems from the aspiration to replicate human-like efficiency in combatting fires. The primary goal is to swiftly detect fire outbreaks and respond proactively to minimize property damage and, most importantly, the loss of human lives. Several prior projects have explored various approaches to robot-guided fire suppression. Some initiatives have employed predefined paths or tracking lines for robot navigation towards fire sources, while others integrated ultrasonic sensors for environmental awareness. However, transitioning these designs to real-time, real-world applications can be challenging. Therefore. Our selected approach involves two key elements: remote control through wireless technology and the integration of the Flame sensor. This choice is driven by the Flame sensor's exceptional fire detection capabilities and the crucial role of fire pumps in effective fire management. In our integrated system, each sensor on the robot operates under the control of an

Arduino microcontroller, enabling seamless coordination and synchronized responses. Augmenting the sensor suite, the robot incorporates a strategically designed water tank, ensuring a constant and readily available supply of extinguishing agent during fire emergencies.

During its operation, the robot engages in random exploration within the environment. However, upon detecting a fire, the robot swiftly initiates a predefined sequence of actions. It redirects itself towards the fire source while simultaneously triggering a warning message sent to a registered phone number associated with the location.

Upon reaching the fire site, the robot takes a cautious approach by halting at a safe distance from the flames. It then activates its specialized fire suppression mechanism, using water as the primary extinguishing agent. Simultaneously, the robot issues an alert to the registered phone number, fostering a holistic and integrated approach to fire

3. Problem Formulation/Identification

Marigold IT Park Fire (Pune): A fire incident at Pune's Marigold IT Park resulted in injuries to 20 people and the successful rescue of 40 individuals, highlighting the urgent need for timely fire detection and effective response mechanisms to minimize casualties and property damage.[1]

Dhayari Workshop Fire (Dhayari): A significant fire outbreak in Dhayari resulted in the complete destruction of workshops housed in tin sheds, necessitating a substantial response effort. Such incidents underscore the importance of early fire detection and automated alerts to mitigate extensive damage.[2]

Commercial Building Fire: A fire incident in a commercial building led to the safe evacuation of 225 individuals. This incident underscores the importance of rapid response and effective evacuation procedures in densely populated environments[3].

PNB Branch Fire (Karol Bagh, Delhi): A fire outbreak within a PNB branch in Delhi's Karol Bagh, fortunately without injuries, highlights the potential risks to lives and property in commercial establishments. It underscores the significance of fire prevention and rapid alert systems[4].

Cuddalore House Fire (IN,s Cuddalore district): Tragedy struck in TN's Cuddalore district when a man accidentally set his house on fire while attempting self-harm, resulting in 5 fatalities. This incident underscores the broader societal impact of fires and the need for early intervention and assistance[5].

Breach Candy Apartment Fire (Mumbai): The recent fire at Mumbai's Breach Candy Apartment on May 27, 2023, serves as a reminder of the unpredictable nature of fire emergencies and the critical role of automated alert systems in residential areas[6].

Kamala Nagar Shanty Fire (Dharavi): A blaze in Dharavi's Kamala Nagar destroyed nearly 100 shanties, highlighting the vulnerability of such communities to fire incidents. This incident emphasizes the need for fire detection and alert systems to protect marginalized communities[7].

4. The design of the firefighting robot

The firefighting robot's design focuses on efficient fire detection and response, combining flame sensors, communication technology, and obstacle avoidance capabilities. The critical components and features of the robot are as follows:

Flame Detection: The robot is equipped with three flame sensors that continuously monitor the surroundings for signs of fire. These sensors operate in the infrared, ultraviolet, or combined spectrum, detecting radiant energy within the range of approximately 400 to 700 nanometers, indicative of flammable conditions[1].

Alert System: When a fire is detected, the robot promptly takes action by triggering an SMS notification to a registered phone number. It can also initiate a fire alarm call to the registered number, allowing for manual intervention and remote control to mitigate further damage and extinguish the fire[2].

Forest Fire Application: The firefighting robot boasts a versatile application, extending to forest fire detection and mitigation. In the event of a forest fire outbreak, the robot performs dual tasks—fire suppression and notification to a registered phone number. This proactive approach helps contain the fire and prevent its escalation[3].

Obstacle Avoidance: The robot incorporates a target-driven obstacle avoidance model to enhance its mobility. It utilizes fuzzy theory and integrates sensor data to control its speed and navigate towards the designated destination, ensuring it can effectively reach the fire location[4].

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Sr. No.	Component	Features and Functionality
1.	Arduino Mega 2560	Microcontroller board with ATmega 2560
2.	Flame sensor	Detects flames or infrared Radiation
3.	Sim 800L	GSM cellular chip for communication
4.	MQ 2 Sensor	Smoke and combustible gas detection
5.	Relay Module	Controls electrical devices on or off
6.	LM 2596 Buck Converter	Steps down voltage and drives load under 3A
7.	Servo sg 90	Micro servo motor used in hobbyist and DIY projects
8.	Mini Water pump (5v)	Uses suction to pump and release water
9.	Bo Moter, Wheel X 4	Components for building robots and vehicles
10.	18650 Battery X 2	Rechargeable lithium battery of 3.7 volts
11.	Mini Breadboard	Small breadboard with adhesive backing
12.	Jumper Wire	Electric wire for connecting remote circuits on printed circuit boards

Table 1. Hardware Components for Circuit Design

5. The architecture of the Alert Automation

The alert automation system plays a pivotal role in the firefighting robot's design, enabling swift and effective responses to fire emergencies. The architecture of this system comprises two core components: the hardware aspect and the software aspect.

Hardware Aspect:
The hardware facet of the alert automation system encompasses the physical components integral to the firefighting robot's functionality. These components are responsible for fire detection, alert triggering, and executing essential actions[1].
Key hardware components in this aspect include flame sensors, communication modules (e.g., Sim 800L GSM cellular chip), smoke and combustible gas detectors (such as the MQ 2 Sensor), locomotion motors (e.g., Bo Motor), and actuation mechanisms (Servo sg 90)[2].
The physical arrangement and design of these components are pivotal to ensuring the robot's effectiveness in detecting and responding to fires[3].

Software Aspect (Utilizing Draw Up):
The software facet of the alert automation system introduces Draw Up, a versatile 3D modeling tool. Although typically associated with architectural, interior design, and civil and mechanical engineering applications, in this context, Draw Up serves as the software platform for controlling and decision-making of the robot[1].
Draw Up is employed to design the robot's control algorithms, navigation logic, and response protocols. It facilitates the creation of a virtual representation of the robot's environment and enables the development of its behavior in response to fire detection[2].
The software aspect also encompasses programming and code development, ensuring seamless communication between hardware components and the control system designed within Draw Up[3].
In summary, the architecture of the alert automation system harmonizes the physical hardware components responsible for fire detection and response with the software component, providing intelligence and control to the firefighting robot. Together, these components empower the robot to identify fires, initiate alerts, navigate obstacles, and take necessary actions to effectively mitigate fire emergencies[4].

Figure 1 (not provided here) likely illustrates the physical arrangement of the mechanical components of the firefighting robot, while the software design within Draw Up governs its decision-making and control processes. This comprehensive approach ensures a holistic and intelligent alert automation system for firefighting and emergency response.

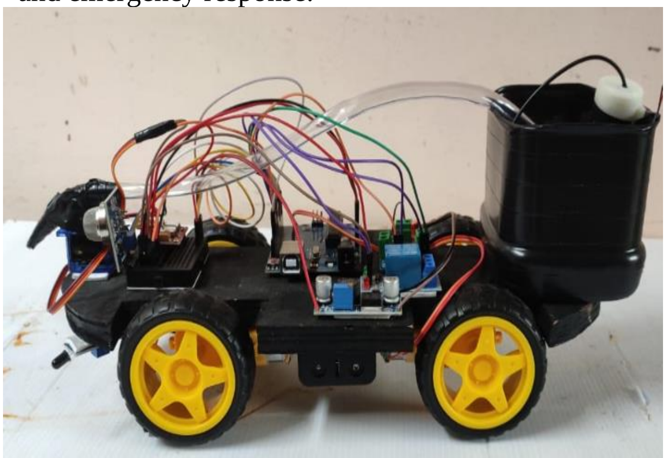

Figure 1. Design of the Alert Automation

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a. Connection between Components

The operation of the firefighting robot hinges on establishing intricate interconnections among its components and the central Arduino microcontroller. These connections are realized through the strategic utilization of jumper wires, creating a complex yet meticulously organized network that guarantees the seamless integration and coordination of critical equipment[1].

Jumper Wires:
Jumper wires act as the physical conduits that link individual hardware components to the Arduino microcontroller. These wires come in varying lengths and types, catering to diverse connection requirements within the robot's circuitry[2].

Arduino Microcontroller:
At the core of the system, the Arduino Mega 2560 microcontroller serves as the central processing unit. It receives data from sensors, processes information, and controls various actuators and modules based on predefined algorithms[3].

Integration:
The intricate mesh of connections, thoughtfully designed and implemented, establishes a crucial link between the hardware components and the Arduino board. This integration ensures the smooth flow of data among sensors, detectors, communication modules, and motors, enabling the robot to respond efficiently to fire emergencies[4].

Coordination:
Through these connections, the Arduino microcontroller continuously receives real-time data from flame sensors, smoke detectors, and other sensors. This data empowers the microcontroller to make informed decisions regarding fire detection, alert generation, and navigation. Consequently, the microcontroller can trigger actions such as sending SMS alerts, activating the water pump for fire suppression, and controlling the robot's movement to reach the fire source[5].

In summary, the connection between components within the firefighting robot constitutes a vital aspect of its functionality. It forms a network of wires that seamlessly links sensors, detectors, actuators, and the Arduino microcontroller, facilitating efficient data exchange and coordinated responses to fire emergencies. This interconnectedness is pivotal in ensuring the robot's ability to detect fires, communicate alerts, and execute firefighting actions with precision and reliability[6].

Figure 2 (not provided here) likely illustrates the physical layout of these connections, demonstrating how jumper wires establish connections between each component and the Arduino board. This visual representation aids in comprehending the intricate interplay among the components and their central control unit.

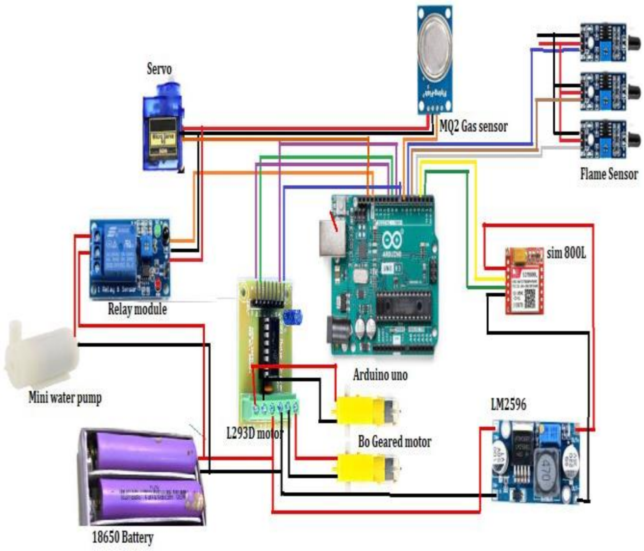

Figure 2. The connection between components and Arduino.

6. Arduino Software

The fire fighting robot's operations are governed by the Arduino software. Arduino programming transcends programming languages, as it involves a compiler that generates binary machine code from any chosen programming language. The Arduino Project offers the Arduino Integrated Development Environment (IDE)—a cross-platform tool coded in Java. This IDE accommodates code written in C and C++, featuring specific conventions for code management. When the fire fighting robot detects a fire, it promptly initiates an alert sequence through interaction with the Arduino software. The robot leverages the SIM800L module to convey fire alerts via a SIM card. To enable this functionality, the Arduino is configured to receive signals from the Sim 800L module. Upon fire detection, the Arduino IDE triggers a multi-step process. It commences by sending an SMS notification to the registered phone number through the software interface. Subsequently, if the fire's temperature surpasses a certain threshold, the Arduino proceeds to initiate a phone call alert.

7. There are several objectives to make this project as following:

This project is driven by several key objectives:

1. Develop and Implement a Firefighting Robot:
The primary objective is to create a firefighting robot capable of autonomous operation or manual control. This robot serves as the central tool for fire detection and suppression[1].

2. Fire Detection:
Enable the robot to swiftly and accurately detect fire outbreaks, particularly in disaster-prone regions. The focus here is on early fire identification to facilitate timely intervention.

3. Prompt Fire Suppression:
Equip the robot with the ability to suppress fires immediately upon detection. The emphasis is on minimizing fire spread and associated damage through swift action[2].

4. Reducing Human Exposure to Danger:
By deploying the firefighting robot, the project aims to decrease the exposure of human firefighters to hazardous conditions, including the risk of injury or fatality during fire combat[3].

5. Cost-Effective Design:
Design and construct the firefighting robot with cost-effectiveness as a priority. This objective ensures the technology's accessibility and affordability for widespread deployment.

6. Obstacle Avoidance:
Implement obstacle avoidance mechanisms in the robot's design to enable safe and efficient navigation, especially in complex and dynamic fire scenarios[4].

7. Safeguarding Human Lives:
The ultimate goal is to protect human lives, particularly those of firefighters who often face significant risks during firefighting operations. Achieving this objective enhances overall safety during such operations[5].

8. Pinpoint Fire Origins:
Develop the capability to pinpoint the precise origin of fire outbreaks, facilitating swift response and containment.

9. Intelligent Fire Detection System:
Outline an intelligent fire detection system based on insights provided in this paper.

10. Comprehend Fire Detection Principles:
Enhance knowledge within the field by comprehending the underlying principles governing the operation of fire detection systems.

9. Conclusion

The successful implementation of an automated firefighting robot, meticulously guided by programmed instructions, has showcased its remarkable efficacy in fire detection and suppression. This project's journey involved aligning the robot's construction with its initial design objectives and incorporating refinements to meet evolving needs and enhancements. Notably, the integration of components such as sensors, the SIM 800L module, and relays onto the PCB, despite the challenge of limited available supply voltage ports from the Arduino, ensured the robot's optimal operational conditions.

The development of code through the Arduino software has played a pivotal role, granting comprehensive control and coordination over the robot's multifaceted functions. Utilizing a robust software library expedited the project realization, further bolstered by real-time simulations that facilitated fine-tuning and validation. It's worth highlighting that the firefighting robot's design, along with the proposed enhancements presented here, has the potential to significantly improve the accuracy and effectiveness of firefighting systems, providing invaluable support to human firefighting efforts.

The concept of this firefighting robot holds substantial promise, transcending its current application to potentially serve diverse contexts and scenarios. Its adaptability and versatility position it as a valuable tool, not only in firefighting but also in addressing a wide range of fire-related challenges.

10. References:

[1] Forest-fire Response System Using Deep-Learning-Based Approaches with CCTV Images andWeather Data‖.: 2022 IEEE International Conference on Advances in Computing.

[2] ―Domestic Smart Fire Fighting Robot with Multisensory Fire Detection and Warning System Using Python IDE‖, 2022, India, Syed Musthak Ahmed, A. Durga Sai Shiva, and Vinit Kumar Gunjan ―.

[3] ―Advances Toward the Next Generation Fire Detection: Deep LSTM Variational Autoencoder for Improved Sensitivity and Reliability ‖-2021 IEEE International Conference onIntelligent Control (LSTM).

[4] Ahmed Murad1 , Oguz Bayat2 , Hamzah M. Marhoon3 ,―Implementation of rover tank firefighting robot for closed areas based on arduino microcontroller‖.2021. Indonesian Journal of Electrical Engineering and Computer Science.

[5] ―Fire Detection andRecognition Optimization Based onrtual Reality Video mage.‖: 2020 IEEE InternationalConference on Intelligent Control, Optimization and Signal Processing Techniques (INCOS) (INCOS) (INCOS) .

[6] ―LPWAN Based IoT Surveillance System for Outdoor Fire Detection‖: 2020 International Computational Intelligence Workshop IEEE.

[7] J Jalani1 , D Misman1 , A S Sadun1 and L C Hong1 , ‒Automatic fire fighting robot with notification‖. 2019

[8] Megha Kanwar1 , Agilandeeswari L.2 , ― IOT Based Fire Fighting Robo‖, 2018.

[9] Z. Lin, F. Chen, Z. Niu, B. Li, B. Yu, H. Jia, and M. Zhang, „„„An active fire detection algorithm based on multi- temporal FengYun-3C VIRR data,‟‟‟ Remote Sens. Environ., vol. 211, pp. 376–387, Jun. 2018.

[10] K. Muhammad, J. Ahmad, and S. W. Baik, „„„Early fire detection using convolutional neural networks during surveillance for effective disaster management,‟‟‟ Neurocomputing, vol. 288, pp. 30–42, May 2018.

[11] H. P. Singh, Akanshu Mahajan, N. Sukavanam, VeenaBudhraja, ‖Control Of An Autonomous Industrial Fire Fighting Mobile Robot‖, DU Journal of Undergraduate Research and Innovation.

[12] Swati A. Deshmukh, Karishma A. Matte and Rashmi A. Pandhare, ―Wireless Fire Fighting Robot‖, International Journal For Research In Emerging Science and Technology.

[13] Dr. J. Subash Chandra Bose, Dr.Marzougui Mehrez, Dr.Ahmed Said Badawy, Dr.Wade Ghribi,Mr.Harun Bangali,Mr.Asif Basha,―Development and designing of fire fighter roboticsusing cyber security‖,2017.

[14] Robot-Assisted Smart Firefighting andInterdisciplinary Perspectives‖, 2016, Proceedings of the 22nd International Conference on Automation & Computing, University of Essex, Colchester,UK.

[15] C. Filizzola, R. Corrado, F. Marchese, G. Mazzeo, R. Paciello, N. Pergola, and V. Tramutoli, „„„RST- FIRES, an exportable algorithm for early-fire detection and monitoring: Description, implementation, and field vali- dation in thecase of the MSG-SEVIRI sensor,‟‟‟ Remote Sens. Environ., vol. 186, pp. 196–216, Dec. 2016.

[16] Firemote.‖[Online].Available:http://www.rylandresearch.co.uk/unman nedvehicles/firemote. [Accessed: 16- Mar-2016].

[17] Welcome to DRB Fatec :::‖ [Online]. Available: http://www.drbfatec.com/frd _center/fighting_m.htm. [Accessed: 16- Mar-2016].

[18] Brokk 50 – remote controlled demolition robot.‖ [Online]. Available: http://www.brokk.com/us/50/. [Accessed: 16-Mar-2016].

[19] CDC - Fire Fighter Fatality Investigation and Prevention Program:Main Page - NIOSH Workplace Safety and Health Topic.‖ [Online]. Available: http://www.cdc.gov/niosh/fire/. [Accessed: 10-Apr-2016].

[20] H.-J. Zhang, N. Zhang, and N.-F. Xiao,

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Volume: 08 Issue: 01 | January - 2024 SJIF Rating: 8.176 ISSN: 2582-3930

„„Fire detection and identification method based on visual attention mechanism,"" Optik, vol. 126, no. 24,pp. 5011– 5018, Dec. 2015.

[21] Lakshay Arora, Prof.AmolJoglekar, ―Cell Phone Controlled Robot with Fire Detection Sensors‖, (IJCSIT) International Journal of Computer Science and Information Technologies, Vol. 6 (3), 2015, 2954-2958.

[22] Arpit Sharma, ReeteshVerma, Saurabh Gupta and Sukhdeep Kaur Bhatia, ―Android Phone Controlled Robot Using Bluetooth‖, International Journal of Electronic and Electrical Engineering.ISSN 0974-2174, Volume 7,Number5 (2014), pp.443-448 A. Hamins, N. Bryner,

[23] Jones, G. Koepke, C. Grant, and A. Raghunathan, ―Smart Firefighting Workshop Summary Report March 24-25, 2014 Arlington, Virginia,‖ National Institute of Standards .

[24] One Fire Detection Method Using Neural Networks‖ (2011) State Key Laboratory of Coal Resources and Mine Safety,China University of Mining and Technology(Beijing), Beijing 100083,China.

[25] Kristi Kosasih, E. Merry Sartika, M. Jimmy Hasugian, danMuliady, ―The Intelligent Fire Fighting Tank Robot‖, Electrical Engineering Journal Vol. 1, No. 1, October 2010.